DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

11 April 1994

MEMORANDUM FOR 410 CES/CEV
ATTN: MR. MARK HANSEN

DISTRIBUTION STATEMENT A
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FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

SUBJECT: Completion of One Year Bioventing Test, Site ST-04 POL Area

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation project at the POL Area has been completed. Figure 1 provides general site information and Table 1 provides a summary of initial, six-month, and one-year fuel biodegradation rates measured at several monitoring points. Biodegradation rates have gradually increased over the one-year pilot test. These increases are best explained by soil temperature increases. Table 2 provides a summary of initial and final soil and soil gas sampling results for total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethylbenzene, and zylenes (BTEX). Based on results from your site and 109 other sites, currently under operation, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend its application throughout ST-04 and at other sites on your installation using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February, 1994.

The objective of the one year sampling effort was not to collect the large number of samples required for statistical significance. It was conducted to give a qualitative indication of changes in contaminant mass. Soil gas samples are somewhat similar to composite samples in that they are collected over a wider area. Thus, they provide a good indication of changes in soil gas profiles and volatile contaminant mass (See Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine

Bioventing Feasibility and Natural Attenuation Potential, February 1994) Soil samples, on the other hand, are discrete point samples subject to large variabilities over small distances/soil types. Given this variability coupled with known sampling and analytical variabilities, a large number of samples would have to be collected to conclusively determine "real" changes in soil contamination. Because of the limited number of samples, these results should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. In situ respiration tests are considered to be better indicators of hydrocarbon remediation than limited soil sampling.

Sampling results indicate that a significant reduction in BTEX has taken place in the soils within the estimated 40-foot treatment radius of the pilot vent well. Due to the inherent variability of in-situ soil samples, TRPH sampling is inclusive at this time, but all other measurements indicate that fuel biodegradation is progressing at a significant rate. AFCEE recommends that the bioventing pilot system continue to operate while planning for an expansion of the system for full-scale remediation. System expansion to a full-scale bioventing system can be contracted through AFCEE. Please contact Patrick E. Haas, AFCEE/ERT, DSN: 240-4314, COM: 210-536-4314, to discuss technical options for full-scale expansion.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. We strongly encourage its use over an arbitrary TPH standard. Attachment 1 summarizes the BTEX/TPH issue and a report sent under separate cover will assist you in negotiating for a BTEX cleanup standard. Our information indicates that Michigan currently regulates to a BTEX standard. TPH is not regulated. In Michigan, three methods exist for the derivation of site-specific action levels (Methods A, B, C). Methods B and C involve site-specific risk-based approaches based on residential and non-residential (e. g. industrial) scenarios respectively. The State of Michigan also considers

polynuclear aromatic hydrocarbons at diesel and waste oil sites (and probably jet fuel sites). However, since these constituents are highly immobile in the subsurface, a Method B or C risk-based approach would most likely identify that these compounds do not drive the risk. In conclusion, a risk-based approach will expedite site closure while reducing overall costs. Please contact Patrick E. Haas, AFCEE/ERT, DSN: 240-4314, COM: 210-536-4314, for details.

In general, quantitative destruction of BTEX will occur over a 1 to 2 year bioventing period. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TPH cleanup is chosen, the pilot and full-scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted 4-6 months after background respiration rates are approached. Also, please note that other common in situ technologies like soil vapor extraction follow the same profile of removing BTEX early, TPH - late.

Because this is a streamlined test and evaluation project, our contract does not provide for additional reports to the base on pilot study results. The interim results report dated 18 Nov 1992 contains as-builts and initial data. This letter summarizes all data collected and provides next step recommendations. AFCEE is no longer responsible for the operation, maintenance, or monitoring of the POL Site bioventing system. We are initiating a contract to extend monitoring at some sites beyond the initial one year test. Monitoring will include soil gas and respiration tests to document hydrocarbon degradation, but will also include the collection of sufficient final soil samples to statistically demonstrate site cleanup. If you are interested, please call us.

The blower and accessories are now base property and should continue to be used on this or other bioventing sites. Although current equipment is explosion proof, under no circumstances should it be used for soil vapor extraction unless appropriate explosion-proof

wiring is provided. If the base does not want the keep the blower or if you have further questions, please contact us at DSN 240-4331 or commercial 210-536-4331.

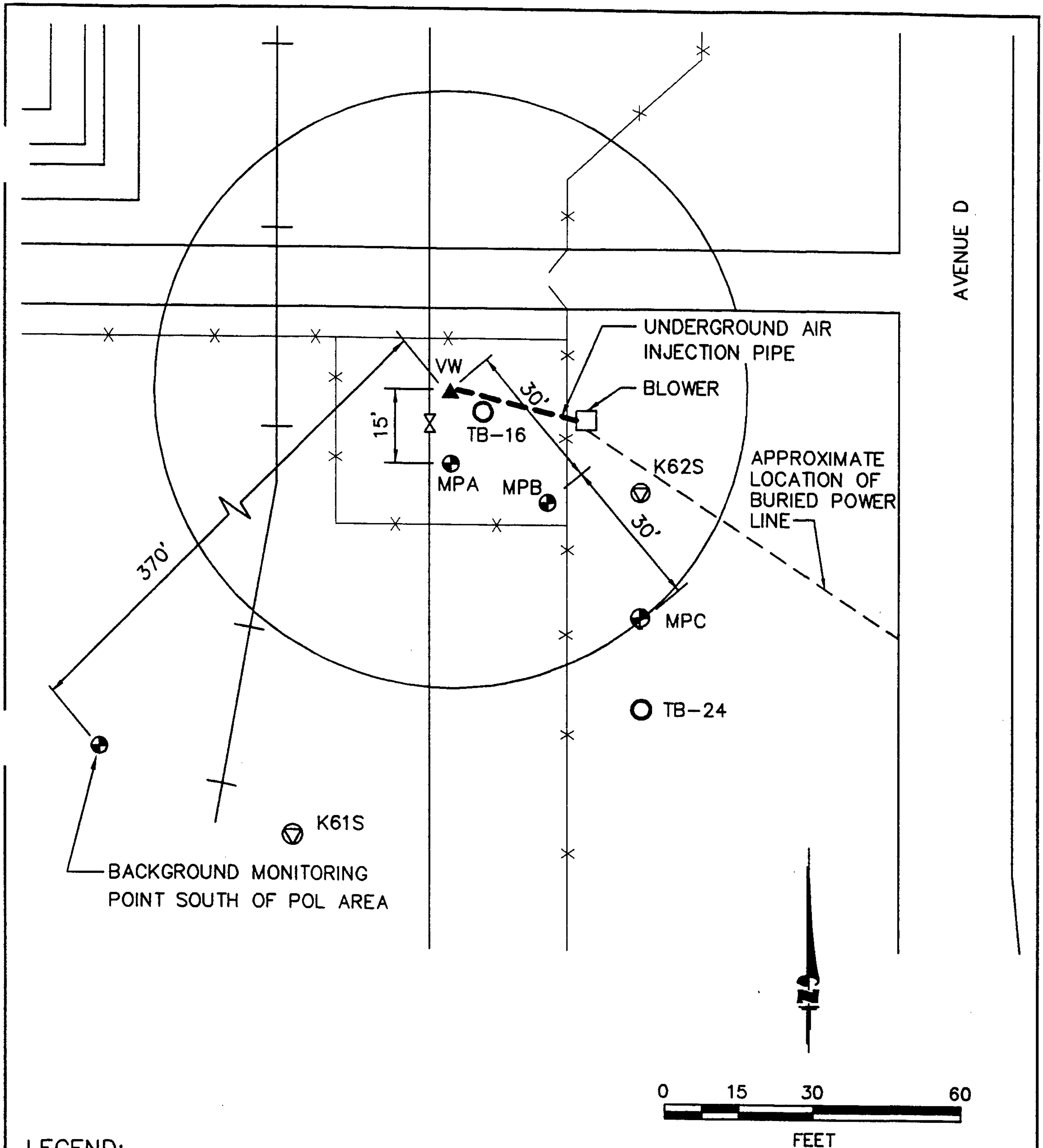
On behalf of the AFCEE/ERT staff, I would like to thank you for your support of this bioventing test and evaluation project. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other DOD, government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

Ross N Miller

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. AFCEE Bioventing Initiative Site Map
2. K. I. Sawyer Bioventing data, Tables 1 & 2
3. "Using Risk-based Standards will Shorten Cleanup Time at Petroleum Contaminated Sites"

cc: AFCEE/ERB



LEGEND:

- VAPOR MONITORING POINT
- CENTRAL VENT WELL
- EXISTING SOIL BOREHOLE LOCATION
- EXISTING MONITORING WELL LOCATION
- FENCE
- RAILROAD

FIGURE 1

AS-BUILT VENT WELL, MONITORING POINT, AND BLOWER LOCATIONS IRP SITE ST-04 POL AREA

K.I. SAWYER AFB, MICHIGAN

ENGINEERING-SCIENCE, INC.
Denver, Colorado

26813-03, 10/15/92 at 10:21

TABLE 1
IRP SITE ST–04 POL AREA
RESPIRATION AND DEGRADATION RATES
K.I. SAWYER AFB, MICHIGAN

	Initial			6–Month[b]			1–Year		
Location–Depth	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA–15	0.0030	634	12.2	0.0028	783	16.7	0.0072	1681	32.8
MPA–35	0.0005	10	––	0.0001	14	––	0.0004	101	––
MPA–60	0.0007	14	8.9	<0.0001	16	8.9	0.0001	20	8.7
MPB–15	0.0020	423	––	0.0048	763	––	0.0059	1377	––
MPB–35	0.0030	477	––	0.0025	448	––	0.0039	789	––
MPC–15	––	––	––	0.0015	238	––	0.0009	203	––
MPC–35	0.0010	159	––	0.0011	175	––	0.0002	35	––

[a] milligrams hydrocarbons per kilogram soil per year
[b] Average moisture between initial and 1–Year readings is used for degradation rate calculation.

TABLE 2
IRP SITE ST-04 POL AREA
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
K.I. SAWYER AFB, MICHIGAN

Analyte (Units)[a]	Sample Location-Depth (feet below ground surface)					
	VW		MPA-35		MPC-15	
Soil Gas Hydrocarbons	Initial[b]	1-Year[c]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	48,000	8.6	70,000	760	5,200	2,700
Benzene (ppmv)	240	0.004	930	ND[d]	7.6	ND
Toluene (ppmv)	140	0.013	390	ND	4.4	ND
Ethylbenzene (ppmv)	10	0.012	17	ND	ND	5
Xylenes (ppmv)	17	0.02	28	0.18	0.80	14
	VW-16		MPA-38		MPB-36	
Soil Hydrocarbons	Initial[e]	1-Year[f]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	1,700	54	670	4,200	1,400	3,620
Benzene (mg/kg)	ND	ND	ND	ND	ND	ND
Toluene (mg/kg)	5.7	ND	5.7	ND	110	ND
Ethylbenzene (mg/kg)	2.5	ND	1.6	ND	25	1
Xylenes (mg/kg)	7.8	ND	4.6	ND	70	23
Moisture (%)	8.8	3.0	19.4	5.8	11.7	9.3

[a] TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram;
TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
$CaCO_3$=calcium carbonate; TKN=total Kjeldahl nitrogen.
[b] Initial soil gas samples collected on September 14-17, 1992.
[c] Final soil gas samples collected on October 27, 1993.
[d] ND=not detected.
[e] Initial soil samples collected on September 14-17, 1992.
[f] Final soil samples collected on October 25, 1993.

USING RISK-BASED STANDARDS WILL SHORTEN CLEANUP TIME AT PETROLEUM CONTAMINATED SITES

MAJOR ROSS N. MILLER

THE AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

The Air Force has identified more than 4,500 sites that require environmental investigation and possible remediation. About 2,500 of these are contaminated with petroleum hydrocarbons such as jet fuel, diesel, gasoline, and heating oil.

Many of the sites that require remediation will be cleaned up based on an established regulatory standard. Many state and federal regulators routinely enforce a soil cleanup standard of 100 mg/kg total petroleum hydrocarbons (TPH). Several states have lowered this standard to 50 mg/kg TPH just for "good measure."

The 100 mg/kg TPH standard is often used across the board--without regard for the type of petroleum hydrocarbon contamination being remediated and with little thought about the risk-based standards on which that figure was established.

But where exactly did the number come from and and how did it become a standard in the first place? The answer can be traced to the California Leaking Underground Fuel Tank Field Manual, or LUFT, a manual designed to provide a consistent approach to underground storage tank spills (State of California, 1989).

The LUFT manual clearly illustrates that the 100 mg/kg TPH standard is based on a "medium" leaching potential of the soluble and toxic fraction of gasoline. The aromatic compounds of benzene, toluene, ethyl benzene, and xylene, known collectively as BTEX, form the most soluble and toxic fraction of fuel.

Different standards apply for diesel because the soluble and toxic fractions make up a lower percentage of the fuel. Also, the appropriate TPH standard changes for different leaching potentials.

It appears that TPH standards were originally developed as a screening tool by the California Department of Health Services (DHS). Using a logical and scientifically sound process, DHS started with state action levels for BTEX in groundwater. They are 0.7, 100, 680, and 620 parts per billion, respectively, and are based on the long-term health effects on a person drinking two quarts of water per day for 70 years.

After establishing acceptable groundwater standards for BTEX, a computer model, based on partitioning kinetics, was used to back-calculate the amount of BTEX in soil that could potentially produce the DHS action levels for BTEX in groundwater. This process was accomplished for low, medium, and high leaching scenarios.

The Air Force is currently investigating bioventing on a large scale to treat their petroleum contaminated sites. Based on a TPH standard of 100 mg/kg, it is estimated that remediation will take up to three years of site operation. However, past research (Miller, 1990) indicates that cleanup based on a risk-based BTEX standard could reduce remediation time to one year and save up to $100 million in unnecessary operation and maintenance costs. Although this cost savings is significant, increased protection of public health is the most important benefit of using a risk-based cleanup standard based on BTEX.

REFERENCES

Miller, Ross N., 1990. A Field Scale Investigation of Enhanced Petroleum Hydrocarbon Biodegradation in the Vadose Zone Combining Soil Venting as an Oxygen Source with Moisture and Nutrient Addition. Ph.D. Dissertation, Utah State University.

Miller, Ross N., R. E. Hinchee, C. M. Vogel, R. R. Dupont, R. C. Sims, D. L. Sorenson, W. J. Doucette, J. J. Skujins, T. Beard, and N. Gupta, 1990. Enhanced biodegradation through soil venting. Final Report. Headquarters Air Force Civil Engineering Support Agency, Tyndall AFB, FL. (In Press)

State of California Leaking Underground Fuel Tank Task Force, 1989. Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup, and Underground Storage Tank Closure. Obtained from State Water Resources Control Board, Sacramento, CA.

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
CUSTOMER SERVICE QUERTIONNAIRE

As part of the AFCEE total quality program, the Technology Transfer Division (ERT) has developed this survey to gauge our performance. Since you have recently been involved with ERT on the activities listed below, we would appreciate it if you would complete the following quERTionnaire and return it to:

HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB, TX 78101-5357

Customer Name: ______________________________
Address: ______________________________
____

Technologies: ______________________________

Please use the following scale to indicate your agreement or disagreement with each statement listed below. Write the number that best reflects your assessment in the space next to the statement.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	2	3	4	5	6

SCORE

1. The innovative technologies currently being advocated by ERT could result in savings at my base. ____

2. The specific technology ERT is testing/applying at my base **will save** the Air Force money. ____

3. The purpose and scope of the work ERT is doing on my base was **well defined and understood** by base and regulatory personnel. ____

4. The work ERT is doing at my base is **well coordinated** with all parties. ____

5. The communication process between my base and ERT is **working well.** ____

6. The application of these technologies will be expanded at my base. ____

7. Please provide additional comments on the reverse and return to AFCEE/ERT.